4.8 The isentropic relations are

$$\frac{p_e}{p_o} = \left(\frac{\rho_e}{\rho_o}\right)^{\gamma} = \left(\frac{T_e}{T_o}\right)^{\frac{\gamma}{\gamma-1}}$$

Hence,

$$T_e = T_o \left(\frac{\rho_e}{\rho_o}\right)^{\frac{\gamma}{\gamma-1}} = (300)\left(\frac{1}{10}\right)^{\frac{1.4-1}{1.4}} = \boxed{155K}$$

From the equation of state:

$$\rho_o = \frac{p_o}{RT_o} = \frac{(10)(1.01x10^5)}{(287)(300)} = 11.73 \text{ kg/m}^3$$

Thus,

$$\rho_e = \rho_o \left(\frac{p_e}{p_o}\right)^{\frac{1}{\gamma}} = 11.73 \left(\frac{1}{10}\right)^{\frac{1}{1.4}} = \boxed{2.26 \text{ kg/m}^3}$$

As a check on the results, apply the equation of state at the exit.

$$p_e = \rho_e RT_e?$$

$$1.01 \times 10^5 = (2.26)(287)(155)$$

$$A_e = \frac{\dot{m}}{\rho_e V_e} = \frac{0.047}{(0.0051)(1500)} = \boxed{0.0061\ \text{ft}^2}$$

4.12 $V_1 = 1500 \text{ mph} = 1500 \left(\frac{88}{60}\right) = 2200 \text{ ft/sec}$

$$C_p T_1 + \frac{V_1^2}{2} C_p T_2 \frac{V_2^2}{2}$$

$$V_2^2 = 2 C_p (T_1 - T_2) + V_1^2$$

$$V_2^2 = 2 (6000)(389.99 - 793.32) + (2200)^2$$

$$V_2 = \boxed{6.3 \text{ ft/sec}}$$

Note: This is a very small velocity compared to the initial freestream v

ft/sec. At the point in question, the velocity is very near zero, and he

nearly a stagnation point.

4.13 At the inlet, the mass flow of air is

$$\dot{m}_{air} = \rho AV = (3.6391 \times 10^{-4})(20)(2200) = 16.0/\text{slug/sec}$$

$$\dot{m}_{fuel} = (0.05)(16.01) = 0.8 \text{ slug/sec}$$

$$\text{Total mass flow at exit} = 16.01 + 0.8 = \boxed{16.81 \text{ slug/sec}}$$

4.20 In the test section

$$\rho = \frac{p}{RT} = \frac{2116}{(1716)(70+460)} = 0.00233 \text{ slug/ft}^3$$

The flow velocity is low enough so that incompressible flow can be assumed. Hence, from Bernoulli's equation,

$$p_o = p + \frac{1}{2}\rho V^2$$

$$p_o = 2116 + \frac{1}{2}(0.00233)\,[150\,(88/60)]^2$$

(Remember that 88 ft/sec = 60 mi/h.)

$$p_o = 2116 + \frac{1}{2}(0.00233)(220)^2$$

$$p_o = \boxed{2172 \text{ lb/ft}^2}$$

4.21 The altimeter meaasures pressure altitude. Thus, from Appendix B, p = 1572 lb/ft^2. The air density is then

$$\rho = \frac{p}{RT} = \frac{1572}{(1716)(500)} = 0.00183 \text{ slug/ft}^3$$

Hence, from Bernoulli's equation,

$$V_{true} = \sqrt{\frac{2(p_o - p)}{\rho}} = \sqrt{\frac{2(1650 - 1572)}{0.00183}}$$

$$V_{true} = 292 \text{ ft/sec}$$

The equivalent airspeed is

$$V_e = \sqrt{\frac{2(p_o - p)}{\rho_s}} = \sqrt{\frac{2(1650 - 1572)}{0.002377}}$$

$$V_e = \boxed{256 \text{ ft/sec}}$$

4.22 The altimeter measures pressure altitude. Thus, from Appendix A, $p = 7.95 \times 10^4$ N/m^2. Hence,

$$\rho = \frac{p}{RT} = \frac{7.95 \times 10^4}{(287)(280)} = 0.989 \text{ kg/m}^3$$

The relation between V_{true} and V_e is

$$V_{true}/V_e = \sqrt{\rho_s / \rho}$$

Hence,

$$V_{true} = 50\sqrt{(1.225)/0.989} = \boxed{56 \text{ m/sec}}$$

4.23 In the test section,

$$a = \sqrt{\gamma RT} = \sqrt{(1.4)(287)(270)} = 329 \text{ m/sec}$$

$$M = V/a = 250/329 = 0.760$$

$$\frac{p_o}{p} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma-1}} = [1 + 0.2\,(0.760)^2]^{3.5} = 1.47$$

Hence,

$$p_o = 1.47p = 1.47\,(1.01 \times 10^5) = \boxed{1.48 \times 10^5\ \mathrm{N/m^2}}$$

4.24 $p = 1.94 \times 10^4\ \mathrm{N/m^2}$ from Appendix A.

$$M_1^2 = \frac{2}{\gamma - 1}\left[\left(\frac{p_o}{p}\right)^{\frac{\gamma-1}{\gamma}} - 1\right] = \frac{2}{1.4 - 1}\left[\left(\frac{2.96 \times 10^4}{1.94 \times 10^4}\right)^{0.286} - 1\right]$$

$$M_1^2 = 0.642$$

$$M_1 = \boxed{0.801}$$

4.25 $$\frac{p_o}{p} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{p_o}{p} = [1 + 0.2\,(0.65)^2]^{3.5} = 1.328$$

$$p = \frac{p_o}{1.328} = \frac{2339}{1.328} = 1761\ \mathrm{lb/ft^2}$$

From Appendix B, this pressure corresponds to a pressure altitude, hence altimeter reading of $\boxed{5000\ \text{ft.}}$
